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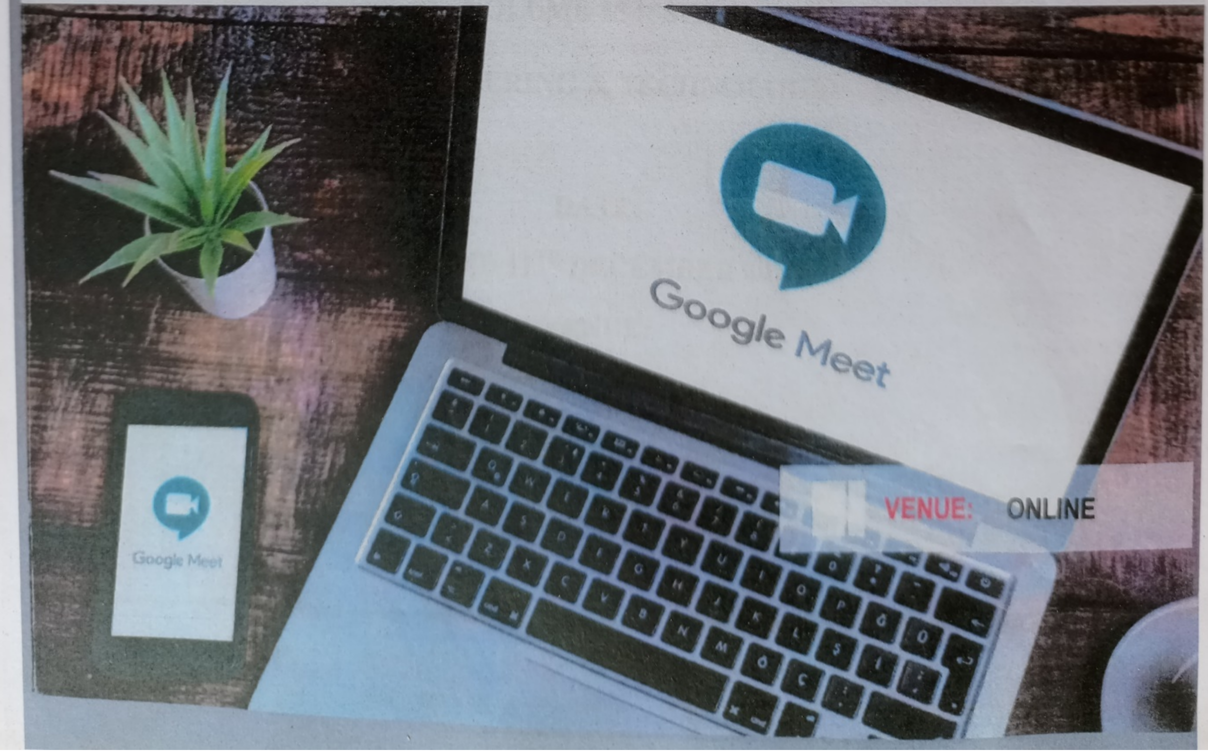

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PROPERTIES OF ASHPHALTIC CONCRETE COMPOSITION FOR DYNAMIC TRAFFIC LOAD APPLICATION

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ABSTRACT

The performance and service life of asphalt pavements are significantly influenced by the dynamic loading imposed by traffic. Understanding the response of hot mixed asphalt to dynamic loading is significant for designing resilient and long-lasting road networks. To design a lasting asphaltic pavement, the properties of the constituent's elements must be checked for adequacy. Hence, this paper presents the physical properties such as AIV, Bulk densities, ACV, Specific gravities and some other properties of the Bitumen. With the preliminary/physical tests conducted so far, the materials demonstrated high possibilities of usage for road pavement because of their strength observed from specific gravities values of 2.40 and 2.65 for dust and fine aggregates, bulk densities of 1.86g/cm^3 for dust, 1.68g/cm^3 coarse and 1.46g/cm^3 sand. The aggregate impact value was found to be 8.78% and crushing value of 20.06%.

Keywords: *Aggregate, Asphaltic Concrete, Composition, Fine, Dust*

1.0 Introduction

Despite the extensive use of hot mixed asphalt in road construction and huge amount spent various road constructions. It usually unclear what happens when road pavement fails. It is not easy then to pinpoint what went wrong and what is to be done. This is due to complex nature of road construction and aftermath of the road usage by the traffic and unregulated number of vehicles and loadings that are to make use of the road pavement leading to gradual deterioration of pavement. Repeated traffic is majorly responsible for the stresses, strain and fatigue that led to pavement failure.

Road infrastructure plays a pivotal role in the economic and social development of nations by enabling efficient transportation of goods and people. Among the various types of road pavement materials, hot mixed asphalt has emerged as a popular choice due to its desirable properties such as flexibility, durability, and cost-effectiveness. However, the performance and service life of asphalt pavements are significantly influenced by the dynamic loading imposed by traffic. Understanding the response of hot mixed asphalt to dynamic loading is significant for designing resilient and long-lasting road networks.

Generally, the two types of pavement in practice in Nigeria are flexible and rigid pavement. A flexible pavement refers to a type of road pavement structure that is constructed using multiple layers of materials with varying properties to withstand the dynamic loads imposed by traffic (Elena and Sergey, 2020) and it is also called flexible pavement because it distributes the load stresses over a wider area through the interaction of the different layers. The key characteristic of flexible pavements is their ability to flex and deform under load, allowing them to accommodate the dynamic forces and reduce the magnitude of stress and strain on the underlying layers (Bingen, 2005).

Asphalt is widely used in road construction due to its cost-effectiveness, durability, and ability to withstand heavy traffic loads. However, the performance and service life of asphalt pavements are significantly influenced by the dynamic loading caused by traffic. The repeated application of traffic loads from moving vehicles can lead to fatigue cracking, rutting, and other distresses, affecting the structural integrity and ride quality of the road and eventual failure. Material properties play a vital role in the response of hot mixed asphalt to dynamic loading. The asphalt mixture composition which includes aggregate, binder and filler significantly influence its strength, stiffness, and fatigue resistance (Bhutta *et al.,* 2019; Li *et al.,* 2020).

Traffic characteristics, such as vehicle speed, axle loads, and tyre configurations, have a direct impact on the dynamic loading experienced by the pavement. Heavy vehicles, such as trucks and buses, generate higher stresses due to their larger axle loads, leading to more significant pavement deformations (Gupta *et al.,* 2018). Furthermore, the frequency and magnitude of the traffic loadings can vary depending on factors like traffic volume, axle load distribution, and pavement roughness, necessitating a detailed analysis of these parameters (Wang *et al.,* 2020).

Environmental conditions, including temperature and moisture variations, also affect the response of hot mixed asphalt to dynamic loading. Temperature changes can cause thermal stresses in the pavement, affecting its stiffness and fatigue performance (Elkashef *et al.,* 2017). Moisture infiltration and its subsequent effect on the asphalt binder can further degrade the pavement's mechanical properties, making it more susceptible to dynamic loading-induced distresses (Zhang *et al.,* 2019).

The pavement structure, including layer thicknesses, base course properties, and sub grade conditions, influences the distribution of stresses and strains caused by dynamic loading. An optimized pavement structure can effectively dissipate the applied loads and minimize damage accumulation (Abdullahi *et al.,* 2021). Therefore, evaluating the influence of different structural configurations on the response of hot mixed asphalt to dynamic loading is essential for designing resilient pavements (Yu *et al.*, 2018).

2.0 Materials and Method

The following materials were used.

Bitumen

Quarry dust

Coarese aggregate

2.1 Methods

In order to achieve the set out objectives, the following methods were adopted

i Site Selection

The selection of the road to be used for this research would be with respect to the traffic intensity. For this research purpose, a failed section of Minna-Bida road would be chosen. The section would be selected such that it captures the major institutions along the road to ensure maximum traffic is achieved.

ii Material Sampling and Preparation

The asphalt production materials such as granite, filler and the binder (60/70 penetration) would be purchased and transported down to Civil Engineering Laboratory of Federal University of Technology, Minna, Niger State.

iii Laboratory Testing

The laboratory tests carried out were in two folds: The physical and the mechanical test. The physical test on both fine and coarse aggregates combined, include the following; Sieve Analysis (BS 812-103.1:1985), Bulk densities (Compacted and un-compacted) (BS 812-2:1995), Specific gravities (BS 812-2:1995), Aggregate impact value (AIV) (BS 812-112:1990), Aggregate crushing value (ACV) (BS 812: Part 110: 1990)

The mechanical test to be carried out is the Marshal stability; this would be achieved by first carrying out the asphalt mix design and the blend proportion to achieve 1200kg of the asphalt. The Bituminous tests conducted include the following; Penetration test (ASTM D5, EN 1426), Ductility test (ASTM D113, EN 13588), Softening point test (ASTM D36, EN 1427), Specific gravity test (ASTM D70, EN 12599), Viscosity test (ASTM D2171 - EN 12596), Flash point test (ASTM D92, EN 22592)

3.0 Results and Discussion

3.1 Sieve Analysis Result

Table 1: Percentage passing sieve sizes for Asphalt concrete composition

Sieve Size	%Passing Coarse	%Passing Fine	%Passing Stone dust
20mm	100	100	0
14mm	96.82	100	0
10mm	66.36	78.29	0
6.3mm	33.26	9.87	0
2.36mm	22.21	2.58	78.05
1.18mm	17.35	2.38	57.2
600µm	13.61	2.15	39.3
300µm	9.98	1.94	28.98
150µm	4.61	1.4	13.81
75µm	3.03	1.15	9.02
Passing 75µm	0	0	0

The aggregates particle grading distributions for each of the components coarse, fine and the dust were carried out and their various percentages retained on the various sieve sizes were calculated. The percentages passing through these sieve sizes were presented in Table 1. These results are required to design for the blended mix of the asphaltic concrete.

3.2 Aggregate Impact Value Result

Table 2: Aggregate Impact Value

Particle size	**6.3mm**	**10mm**
Weight of mold w1(g)	2618g	2618g
Weight of mold + sample w2(g)	3328g	3345g
Weight of sieved sample through sieve 2.36mm w3(g)	67g	59g
Impact value (%)	9.44	8.12
Average Impact value (%)	8.78	

Table 2: Aggregate Crushing Value

Particle size	**6.3mm**	**10mm**
Weight of mold w1(g)	12700	12700
Weight of mold + sample w2(g)	16600	16300
Weight of sieved sample through sieve 2.36mm (w3) g	805	718
Crushing value (%)	20.06	19.94
Average Crushing value (%)	20.06	

The aggregate impact value was found to be 8.78% while that of the crushing value was 20.06% which falls within the standard range of 0 to 30%, hence the aggregate is strong enough for road application.

3.3 Bulk Density Result

Table 3: Uncompacted Bulk density result for filler (sand)

TRIAL NO	1	2
Weight of empty moldW1 (g)	270.21	270.21
Weight of mold + sampleW2 (g)	640.83	656.48
Weight of Sample W3 (g)	370.62	386.27
Volume of mold cm³	264.00	264.00
Bulk Density (g/cm³)	1.40	1.46
Average Bulk Density	1.43	

Table 4: Compacted Bulk density result for filler (sand)

TRIAL NO	1	2
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	677.34	668.67
Weight of Sample W3 (g)	407.13	398.46
Volume of mold (cm³)	264.00	264.00
Bulk Density (g/cm³)	1.54	1.51
Average Bulk Density	1.53	

Table 5: Uncompacted Bulk density result for dust

TRIAL NO	1	2
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	706.00	702.84
Weight of Sample W3 (g)	435.79	432.63
Volume of mold (cm³)	264.00	264.00
Bulk Density (g/cm³)	1.65	1.64
Average Bulk Density (g/cm³)	1.65	

Table 6: Compacted Bulk density result for dust

TRIAL NO	**1**	**2**
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	764.06	755.91
Weight of Sample W3 (g)	493.85	398.46
Volume of mold (cm³)	264.00	264.00
Bulk Density (g/cm³)	1.87	1.84
Average Bulk Density (g/cm³)	1.86	

Table 7: Uncompacted Bulk density result for Coarse aggregate

TRIAL NO	**1**	**2**
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	706.07	707.40
Weight of Sample W3 (g)	435.86	437.19
Volume of mold (cm³)	264.00	264.00
Bulk Density (g/cm³)	1.65	1.66
Average Bulk Density	1.66	

Table 8: Compacted Bulk density result for Coarse aggregate

TRIAL NO	**1**	**2**
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	712.20	713.70
Weight of Sample W3 (g)	441.99	433.49
Volume of mold cm³	264.00	264.00
Bulk Density	1.67	1.68
Average Bulk Density (g/cm³)	1.68	

Table 9: Uncompacted Bulk density result for Sand

TRIAL NO	**1**	**2**
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	638.70	633.20
Weight of Sample W3 (g)	368.49	362.99
Volume of mold (cm³)	264.00	264.00
Bulk Density (g/cm³)	1.40	1.37
Average Bulk Density (g/cm³)	1.39	

Table 10: Compacted Bulk density result for Sand

TRIAL NO	**1**	**2**
Weight of empty mold W1 (g)	270.21	270.21
Weight of mold + sample W2 (g)	654.20	658.50
Weight of Sample W3 (g)	383.99	388.29
Volume of mold cm³	264.00	264.00
Bulk Density	1.45	1.47
Average Bulk Density (g/cm³)	1.46	

Generally, the un-compacted bulk densities were less than the compacted ones; this is due to the packing of particles as a result of compacting. The dust has the highest range of the bulk density with a percentage increase of compacted density for about 13% of the un-compacted density. The components have a reasonably high bulk density which made them suitable for road application.

3.4 Specific Gravity

Table 11: Specific gravity for fine aggregate (Sand)

No. of Trials	**1**	**2**
Jar No.	A2	C
Mass of empty cylinder m1 (g)	46.0	68.9
Mass of cylinder + sample m2 (g)	97.8	133.3
Mass of Cylinder + sample + water m3 (g)	177.1	208.2
Mass of cylinder + water m4 (g)	144.8	168.2
Specific Gravity (Gs)	2.66	2.64
Average Specific Gravity (g/cm³)	2.65	

Table 12: Specific gravity for dust aggregate

No. of Trials	**1**	**2**
Jar No.	A2	C
Mass of empty cylinder m1 (g)	46.0	68.9
Mass of cylinder + sample m2 (g)	108.1	131.9
Mass of Cylinder + sample + water m3 (g)	183.4	207.0
Mass of cylinder + water m4 (g)	150.0	168.5
Specific Gravity (Gs)	2.16	2.57
Average Specific Gravity (g/cm³)	2.40	

The specific gravity results shows that the value for sand is higher than that of dust, however, this means that they are respectively for sand and dust 2.65 and 2.40 stronger than the equal volume of water.

3.5 Flash and Fire Point Result

Table 13: Flash and point result

NO OF TRIALS	FLASH POINT	FIRE POINT
1	350°C	370°C
2	352°C	372°C

The flash and fire point results as presented in Table 13 shows that the bitumen has enough resistance to fire since the result falls within the standard range.

4.0 Conclusion

With the preliminary/physical tests conducted so far, the materials demonstrated high possibilities of usage for road pavement because of their strength observed from specific gravities values of 2.40 and 2.65 for dust and fine aggregates, bulk densities of 1.86g/cm^3 for dust, 1.68g/cm^3 coarse and 1.46g/cm^3 sand. The aggregate impact value was found to be 8.78% and crushing value of 20.06%

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